Training-Free Coverless Multi-Image Steganography with Access Control

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Image Steganography

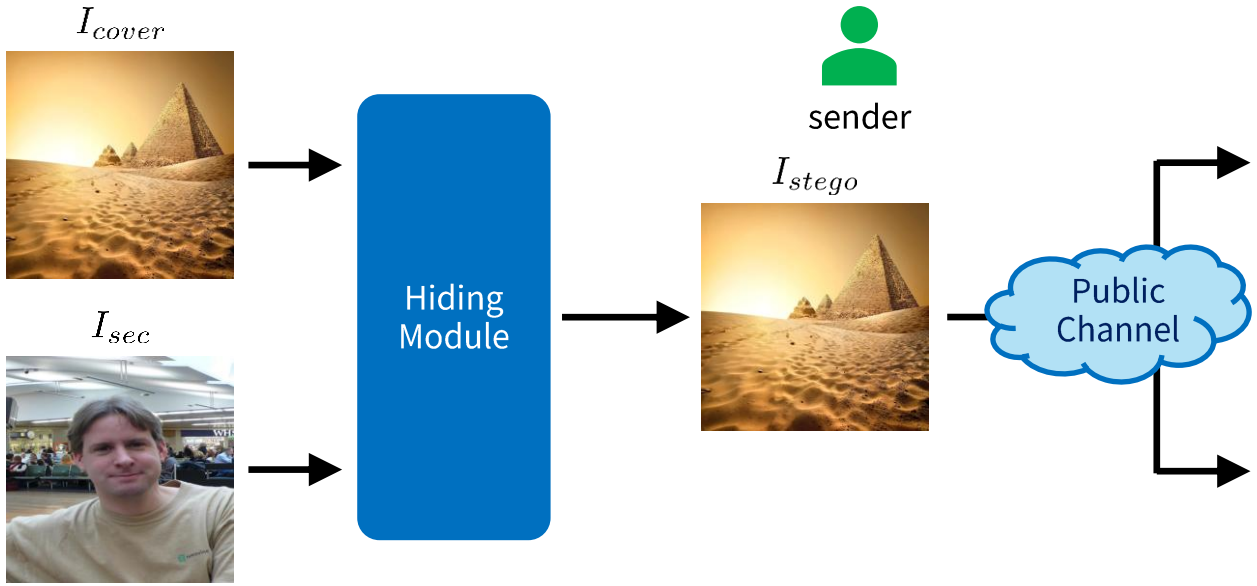


Image Steganography

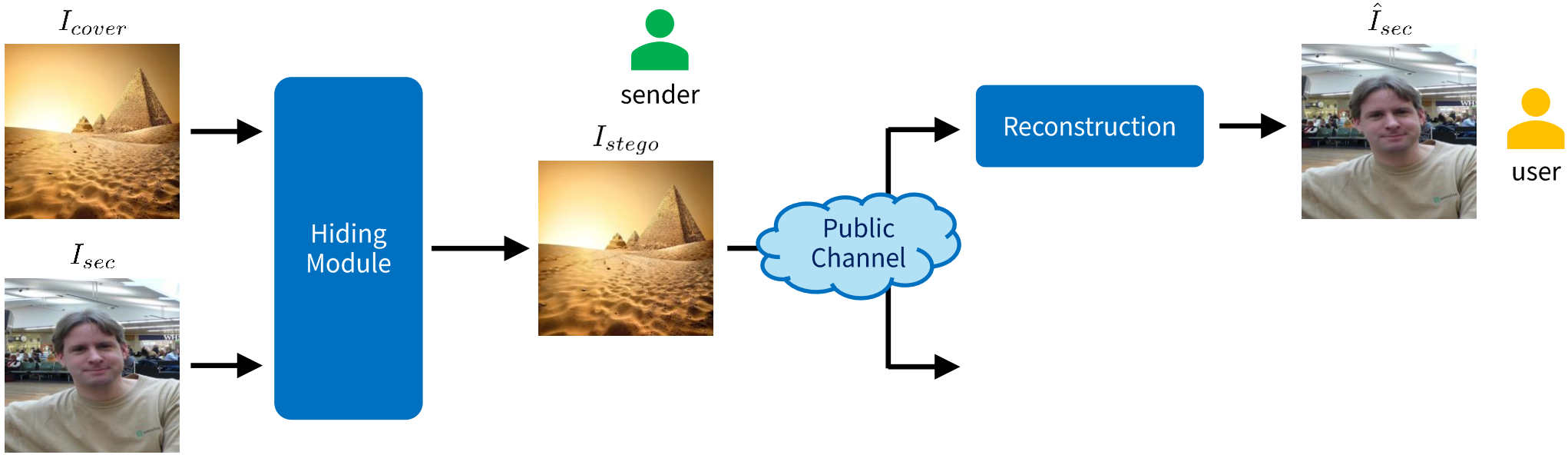
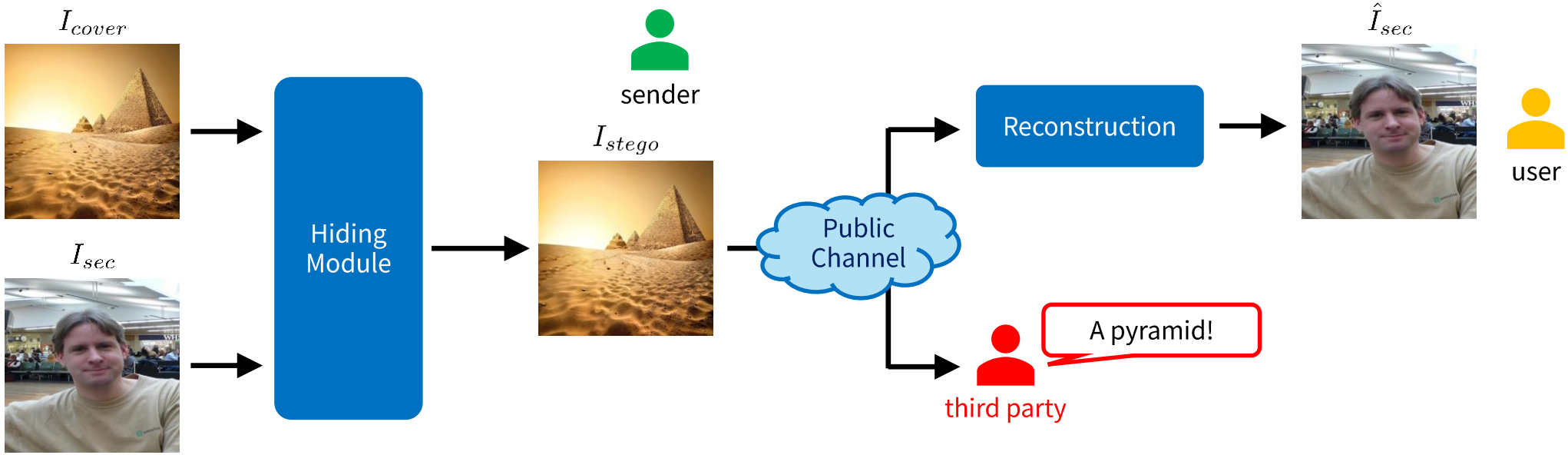
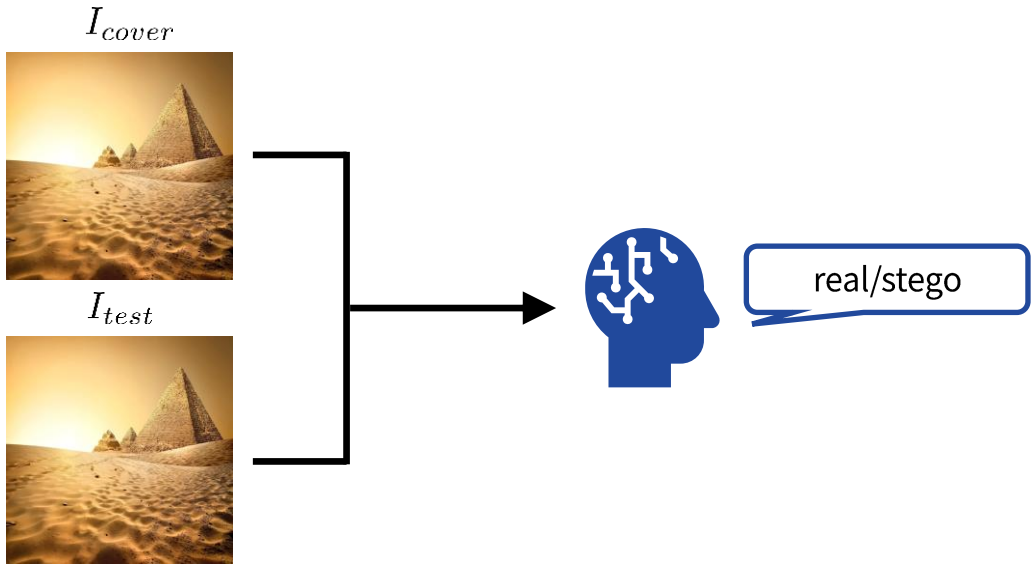


Image Steganography



Challenges

Challenge 1: Security



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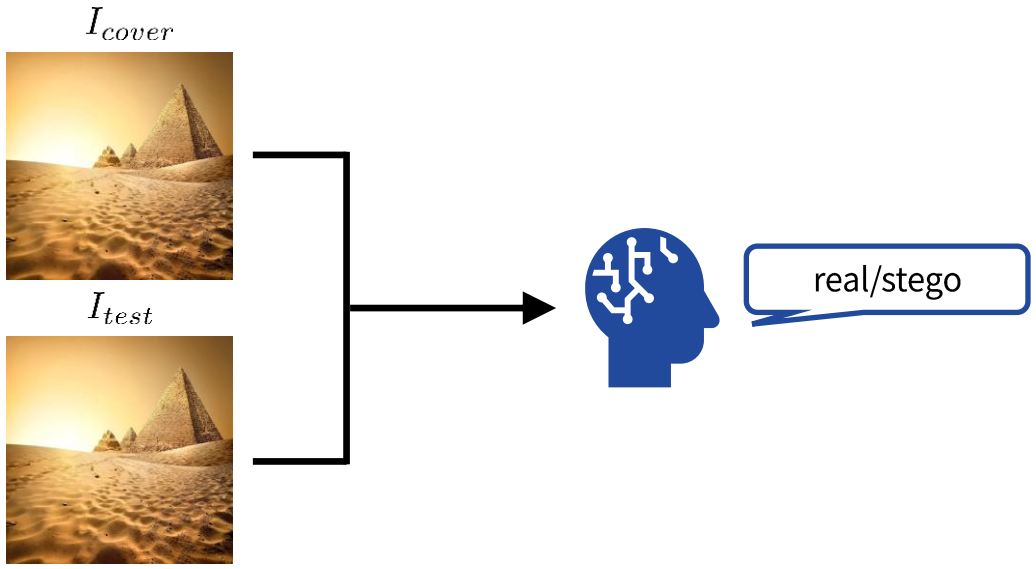
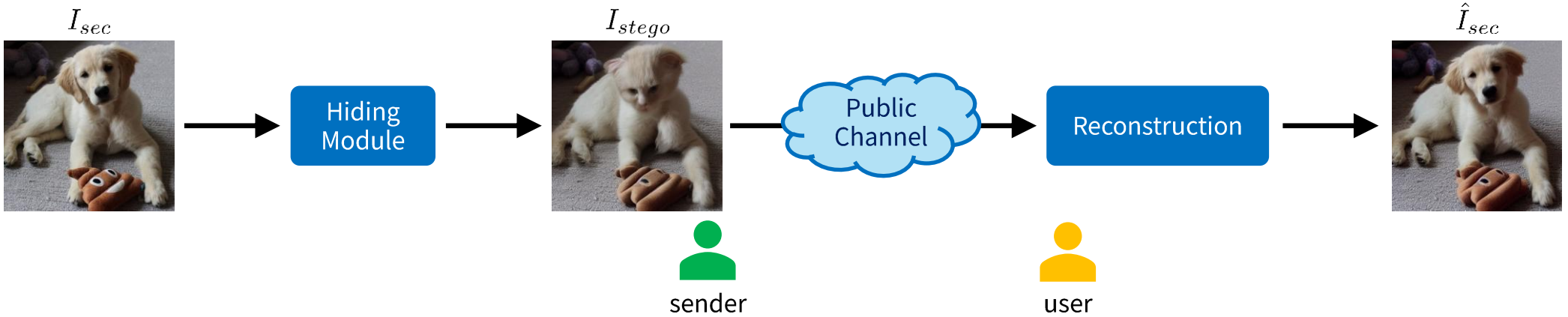


Solution 1: Coverless Image Steganography (CIS)



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Challenge 2: Capacity

- Existing training-free CIS methods mainly support hiding only a **single** image.
- Training generative models is **resource-intensive**.

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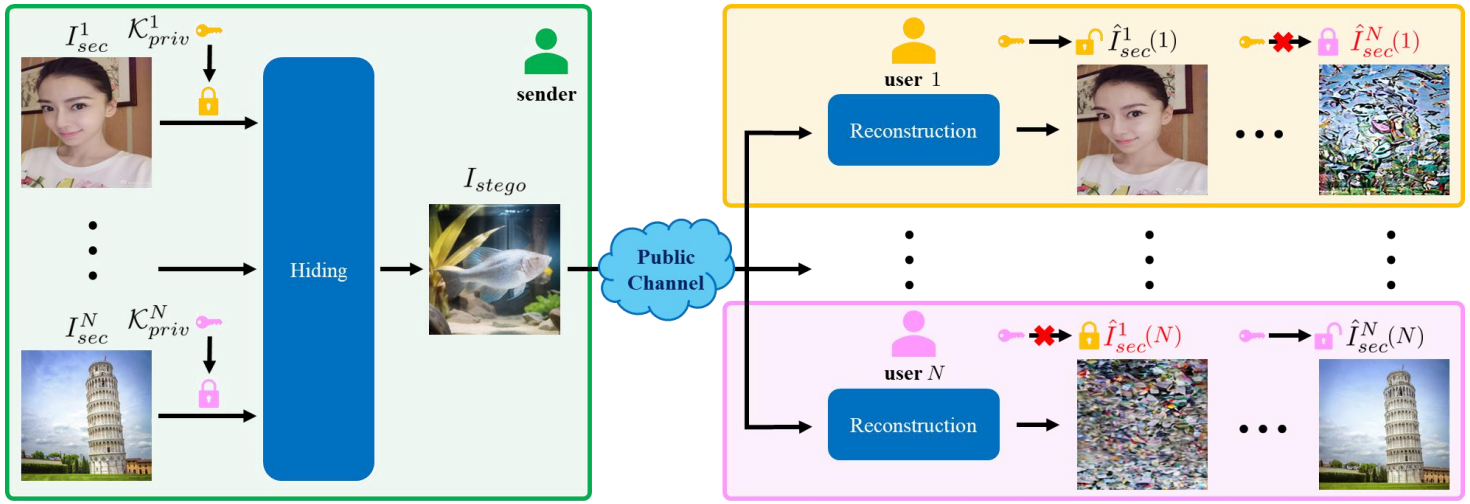
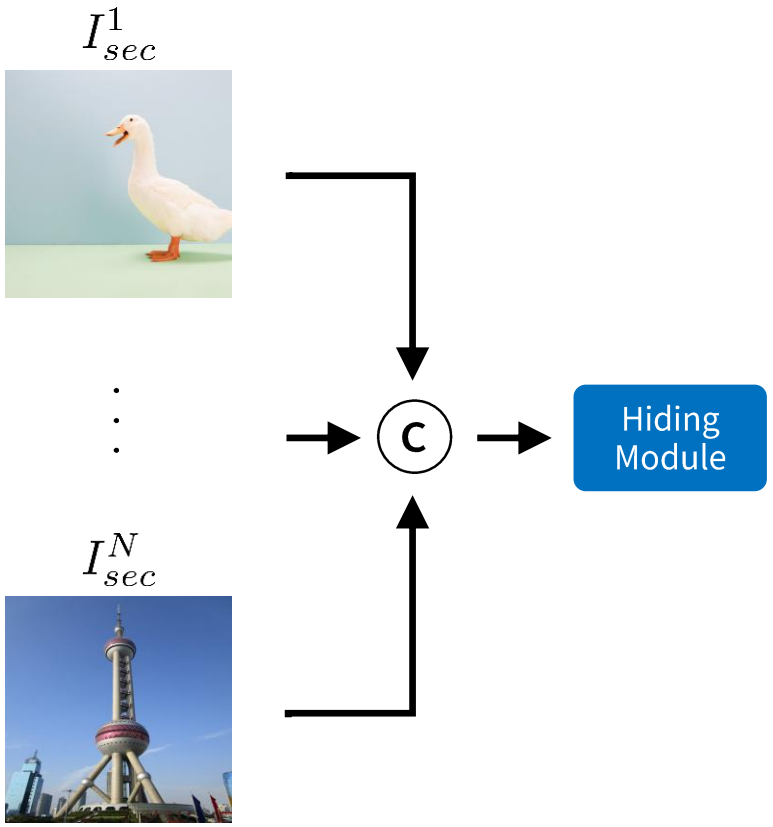
Our Contribution

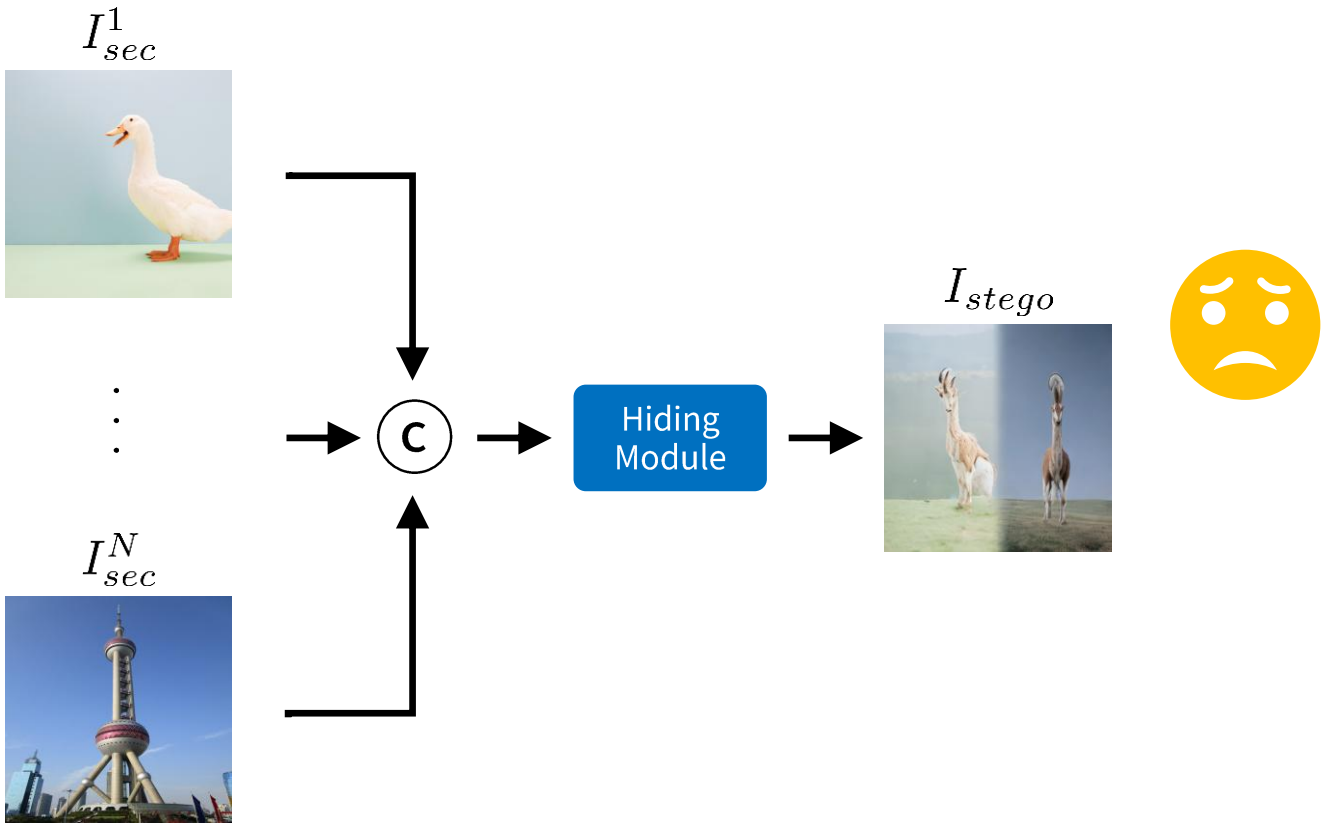
- **Training-free Coverless Multi-image Steganography with Access Control**



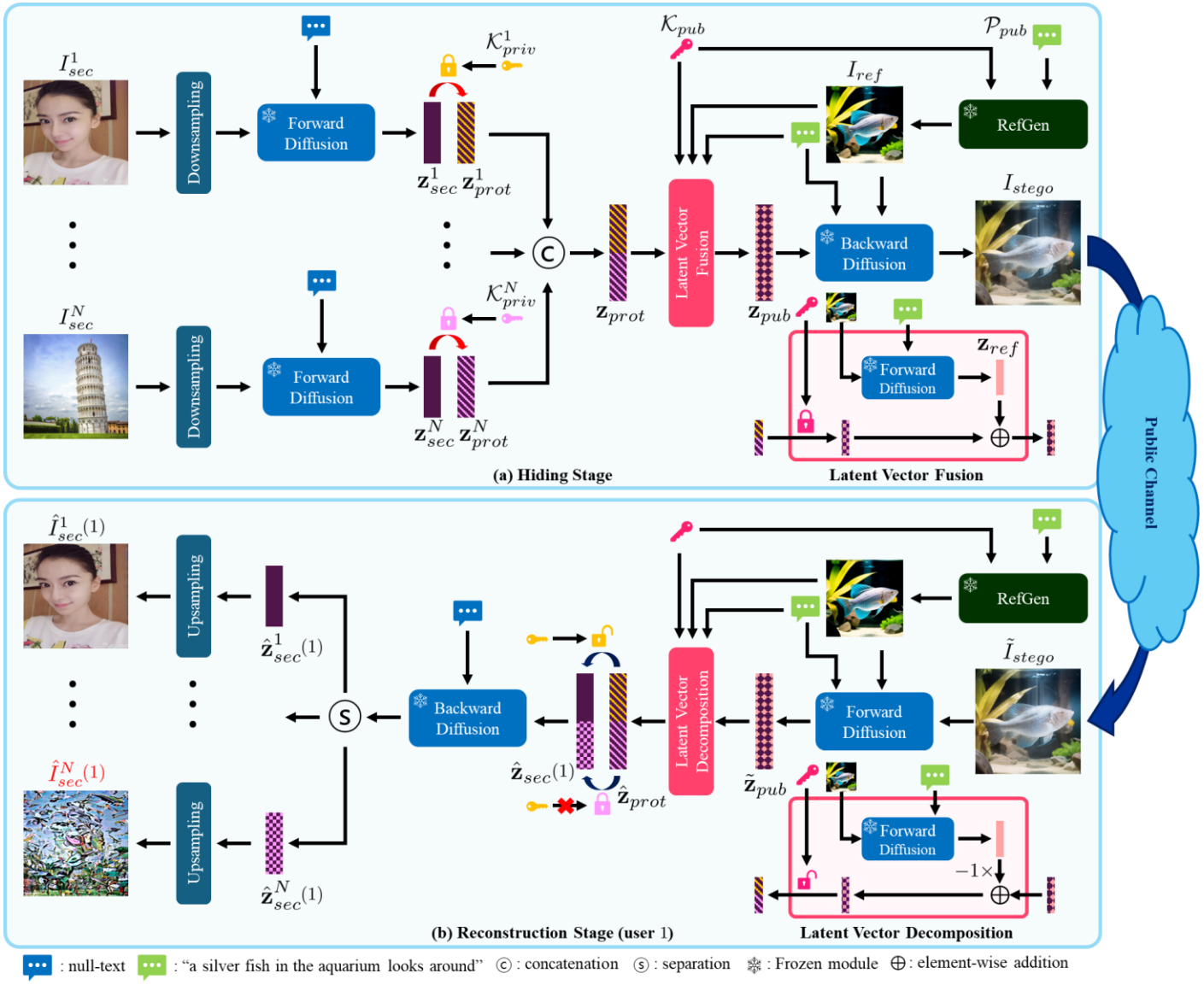
Naïve Idea: Concatenation



Problem: Residual Structural Patterns



Overall Architecture



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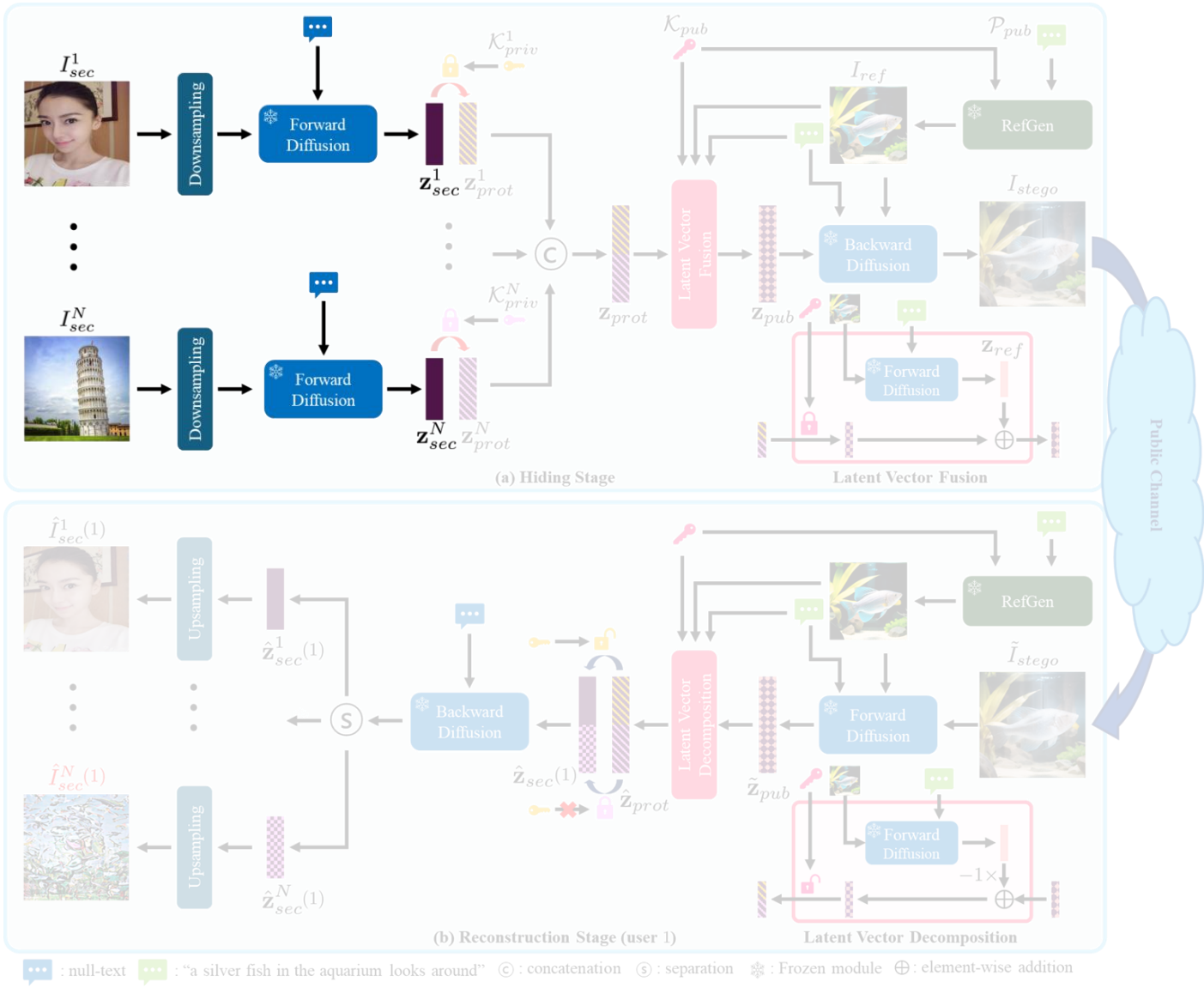

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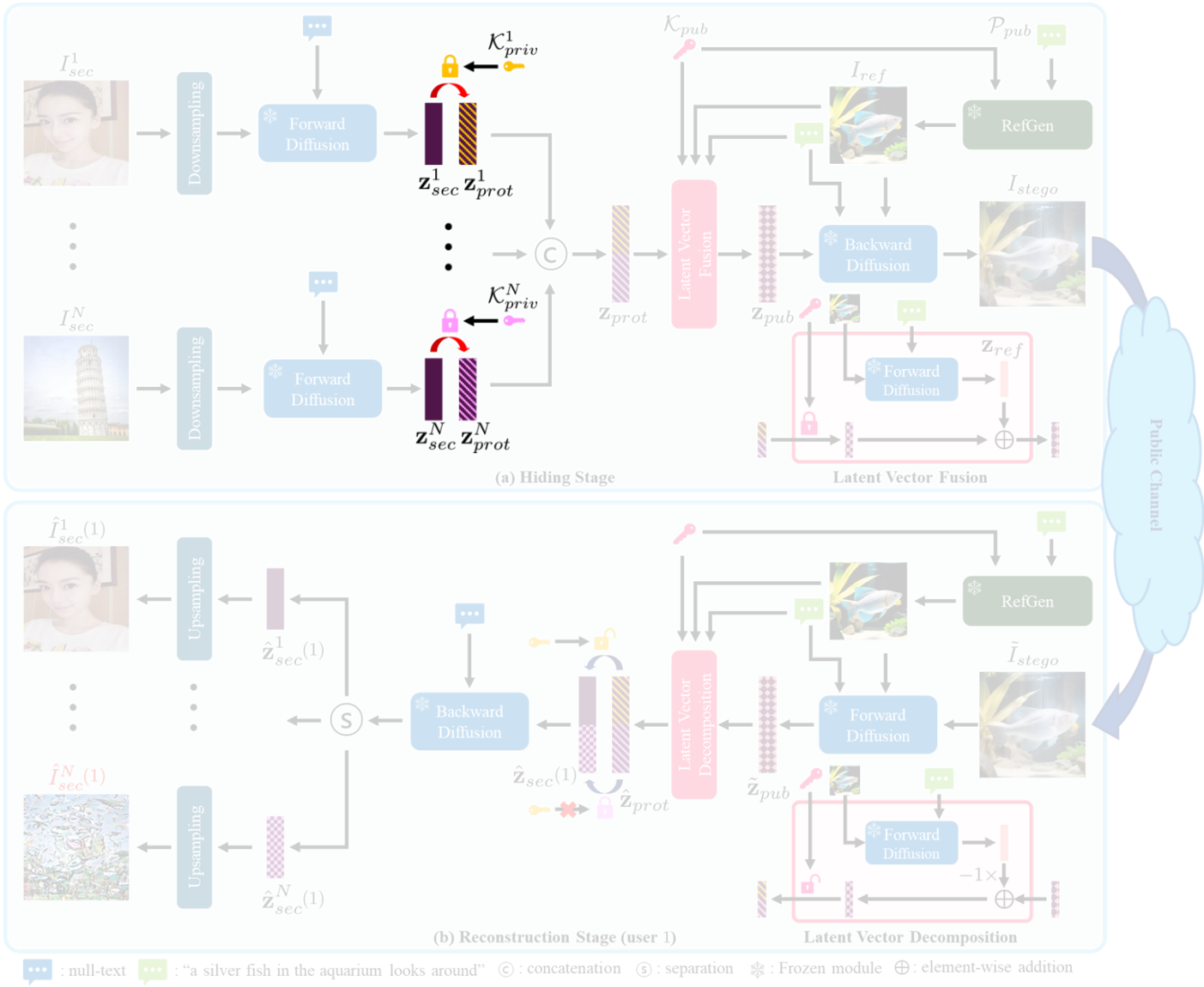

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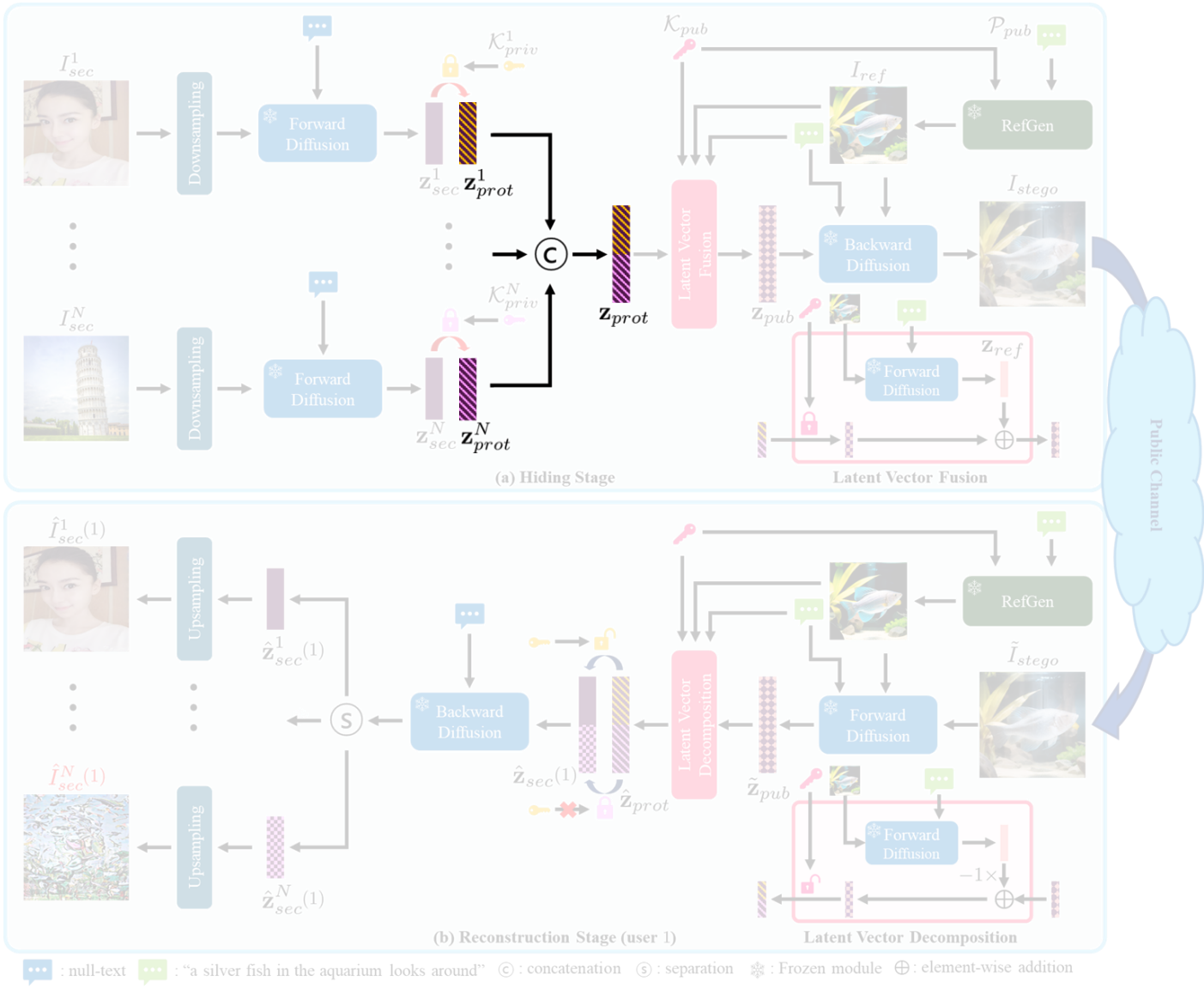

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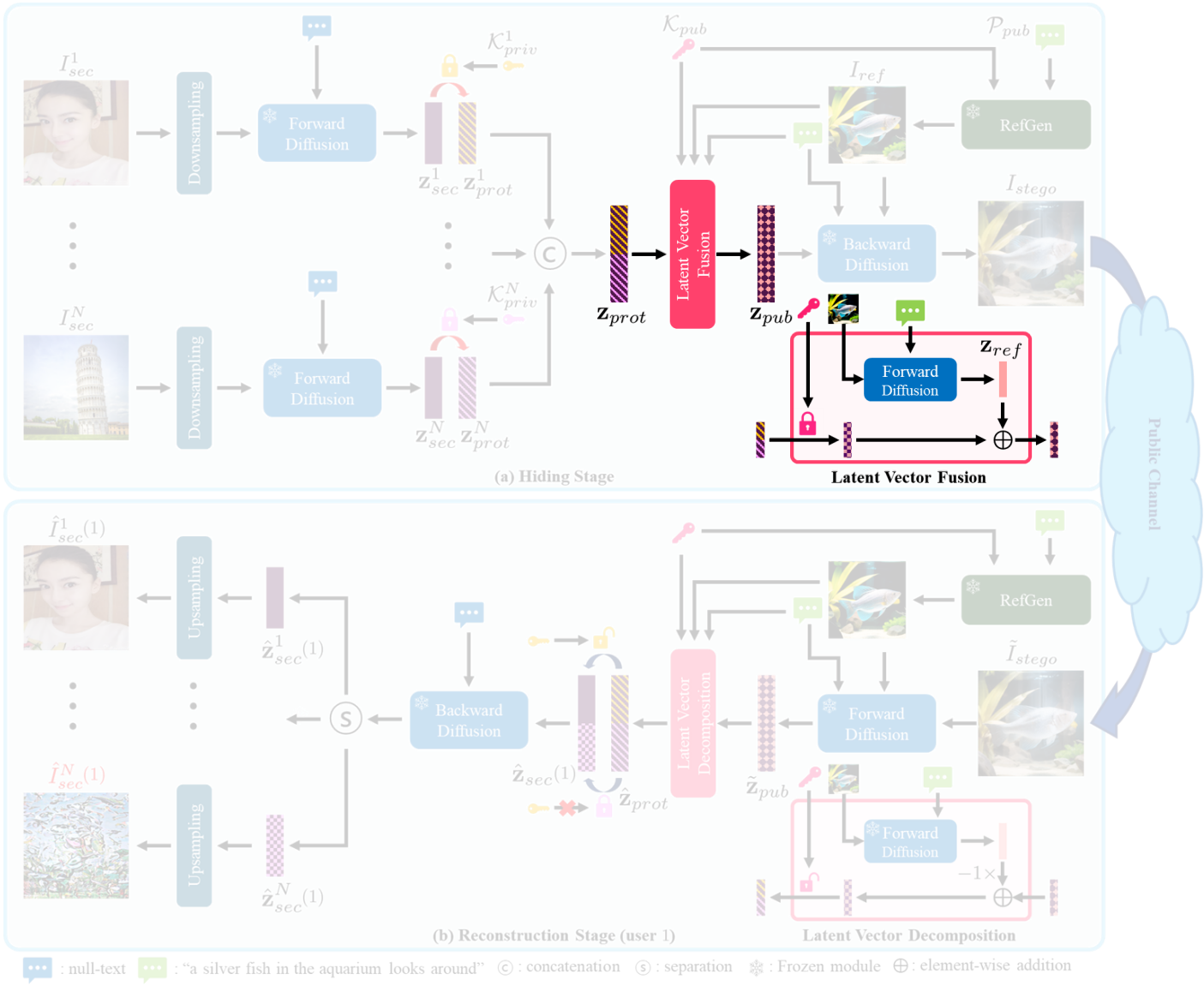

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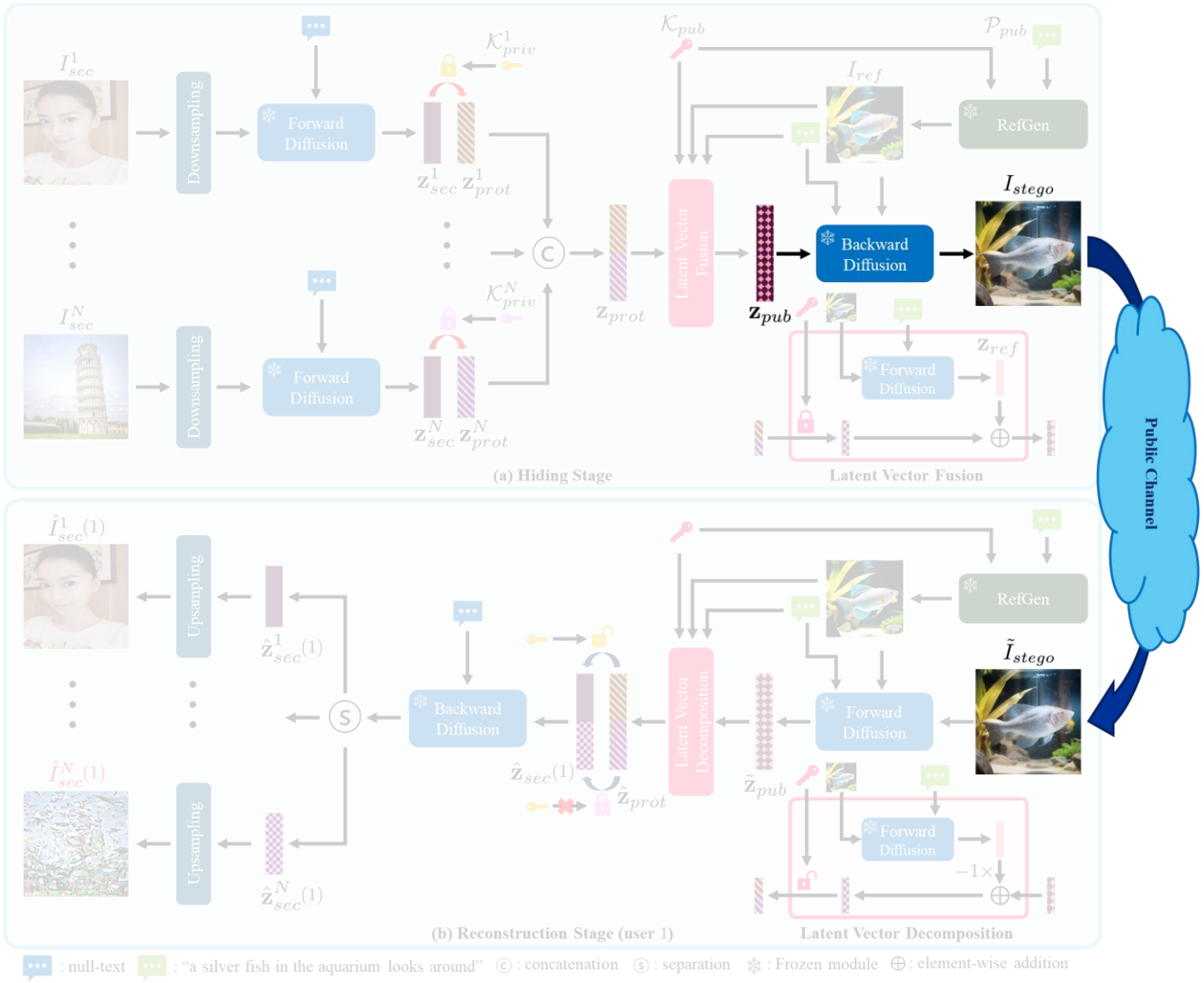

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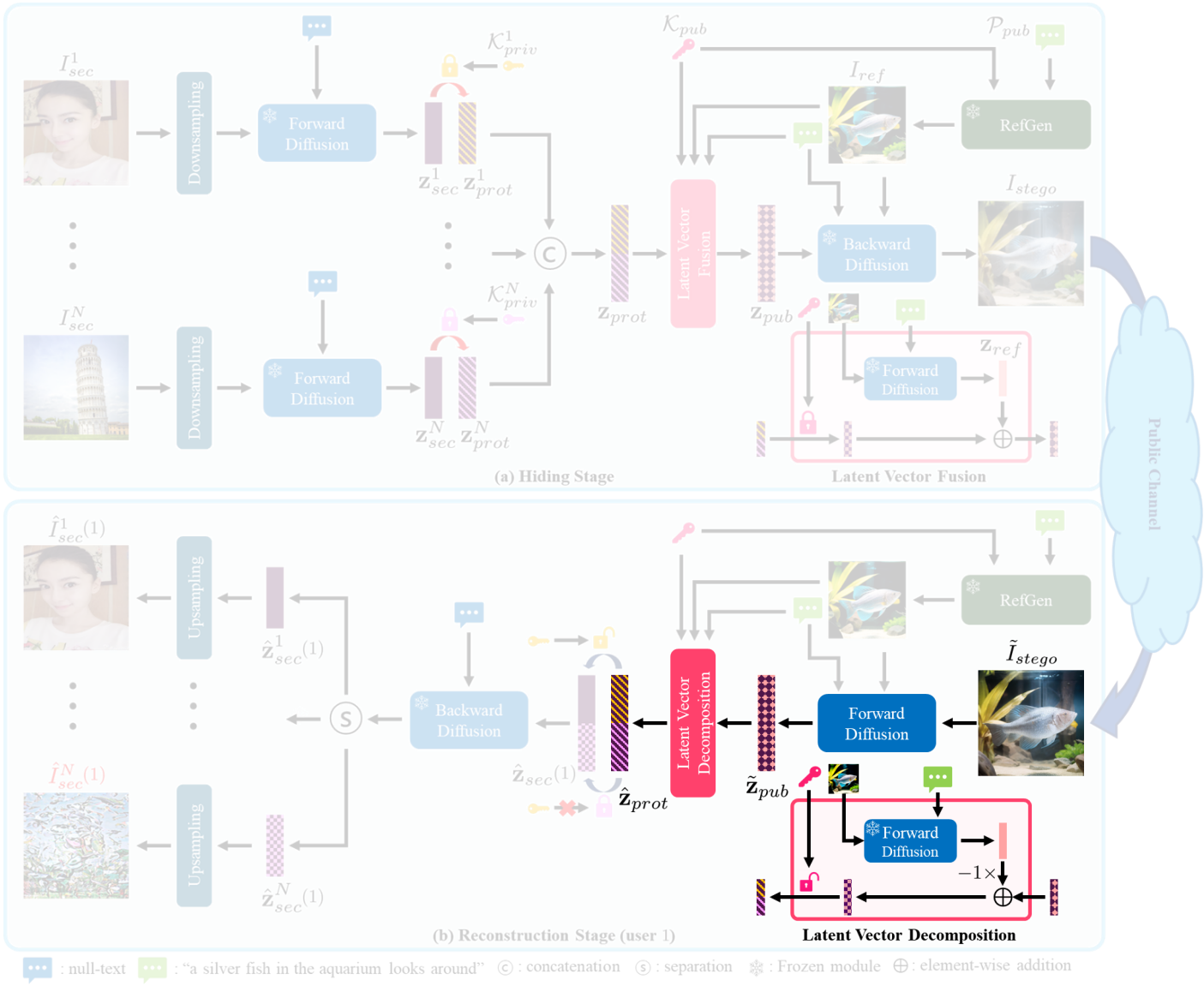

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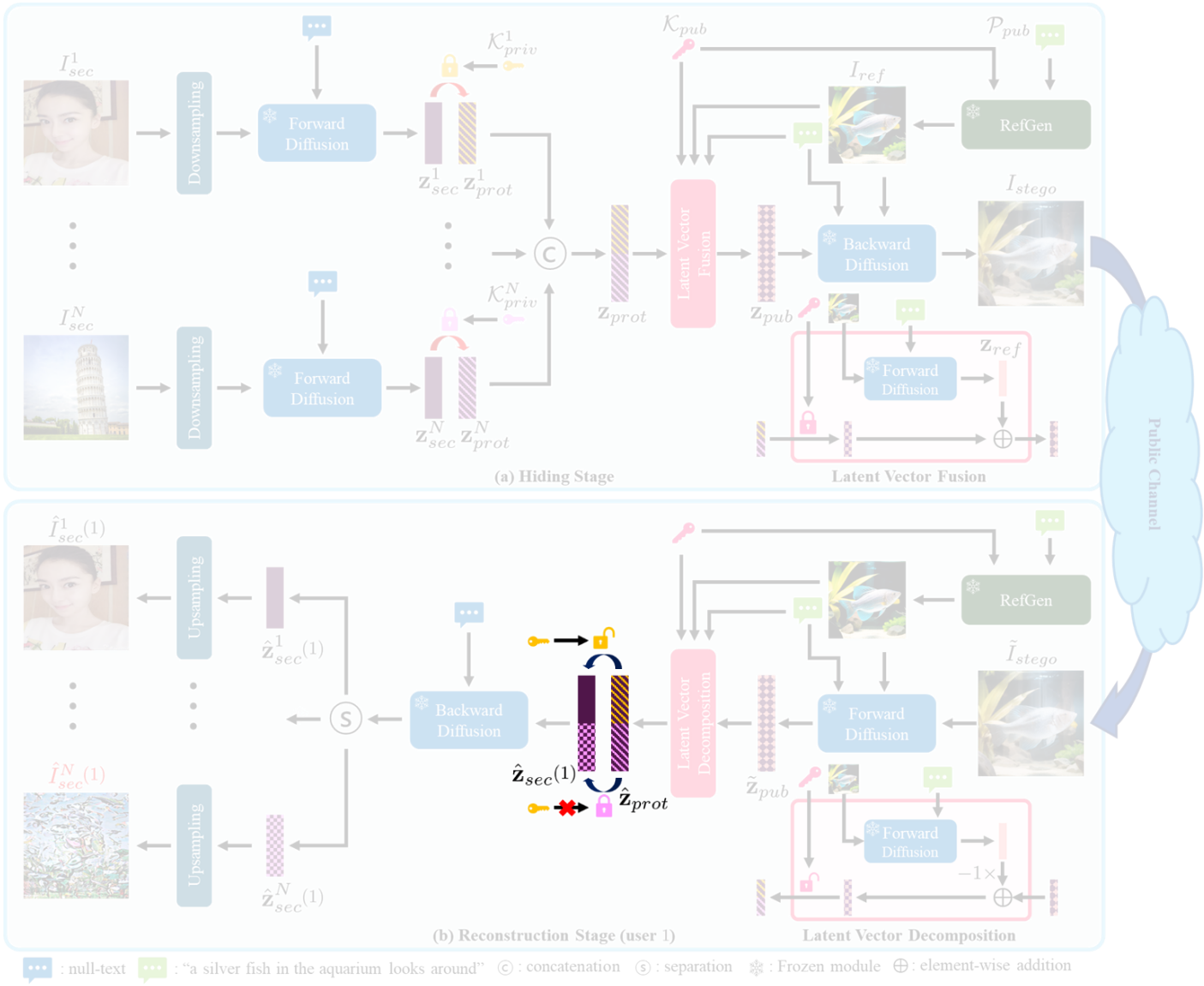

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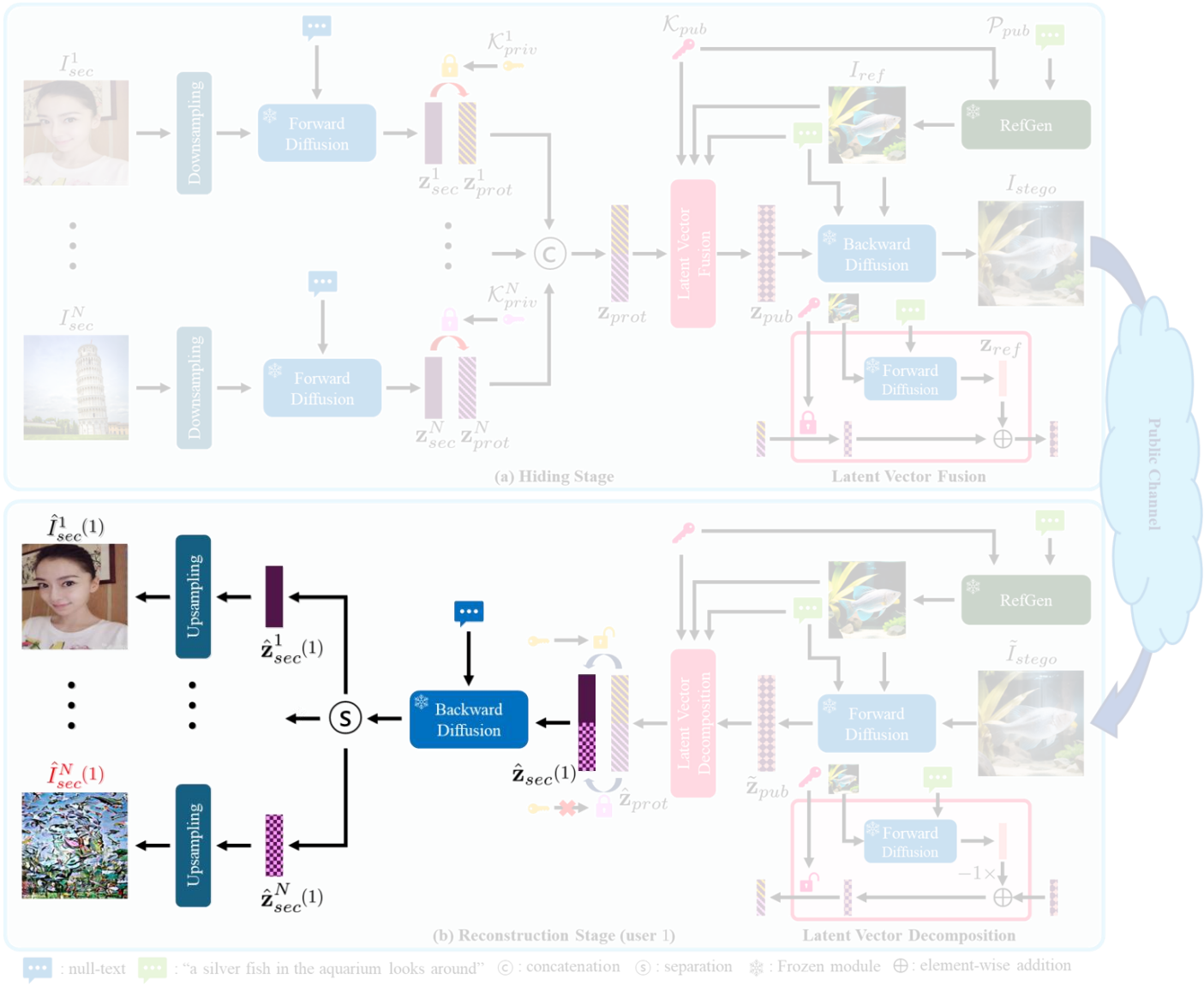
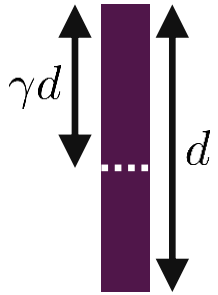


Key Components

Random Basis

- Multiplication with an orthonormal matrix



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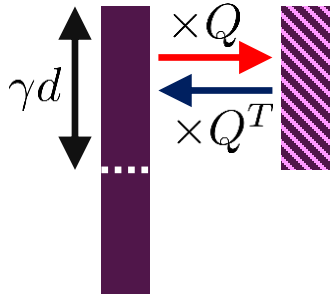

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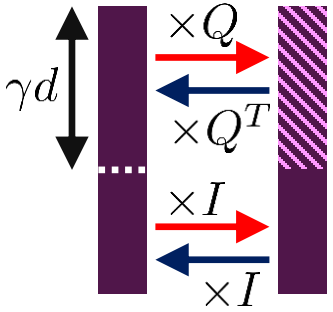
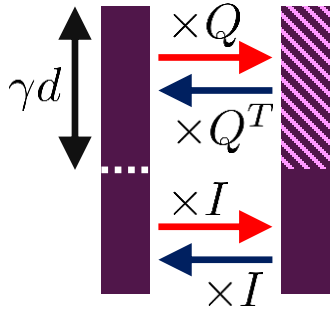


Key Components

Random Basis

- Multiplication with an orthonormal matrix
- Security Analysis
  - Security metric: $R_L = \frac{1}{m} I(I_{sec}; \hat{I}_{sec})$
  - Main Result



Theorem 3.1. *Assume that all variables are quantized with sufficiently small step size Δ. For sufficiently large m, the information leakage under the Random Basis mechanism with strength $\gamma > 0$ satisfies*

$$R_L \approx O\left(\frac{-\log \Delta + \log m}{m} + (1-\gamma)(-\log \Delta + 1)\right).$$

- ✓ In practice, the first term becomes negligible since $\Delta \approx 10^{-7}$ (float32), $m \approx 10^6$ (for a $512 \times 512 \times 3$ image).
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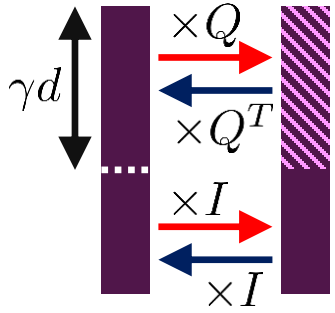

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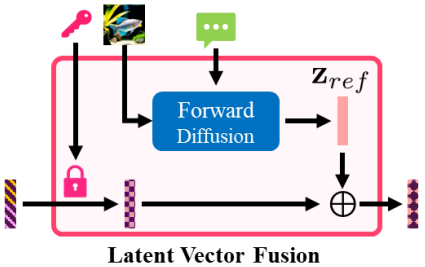
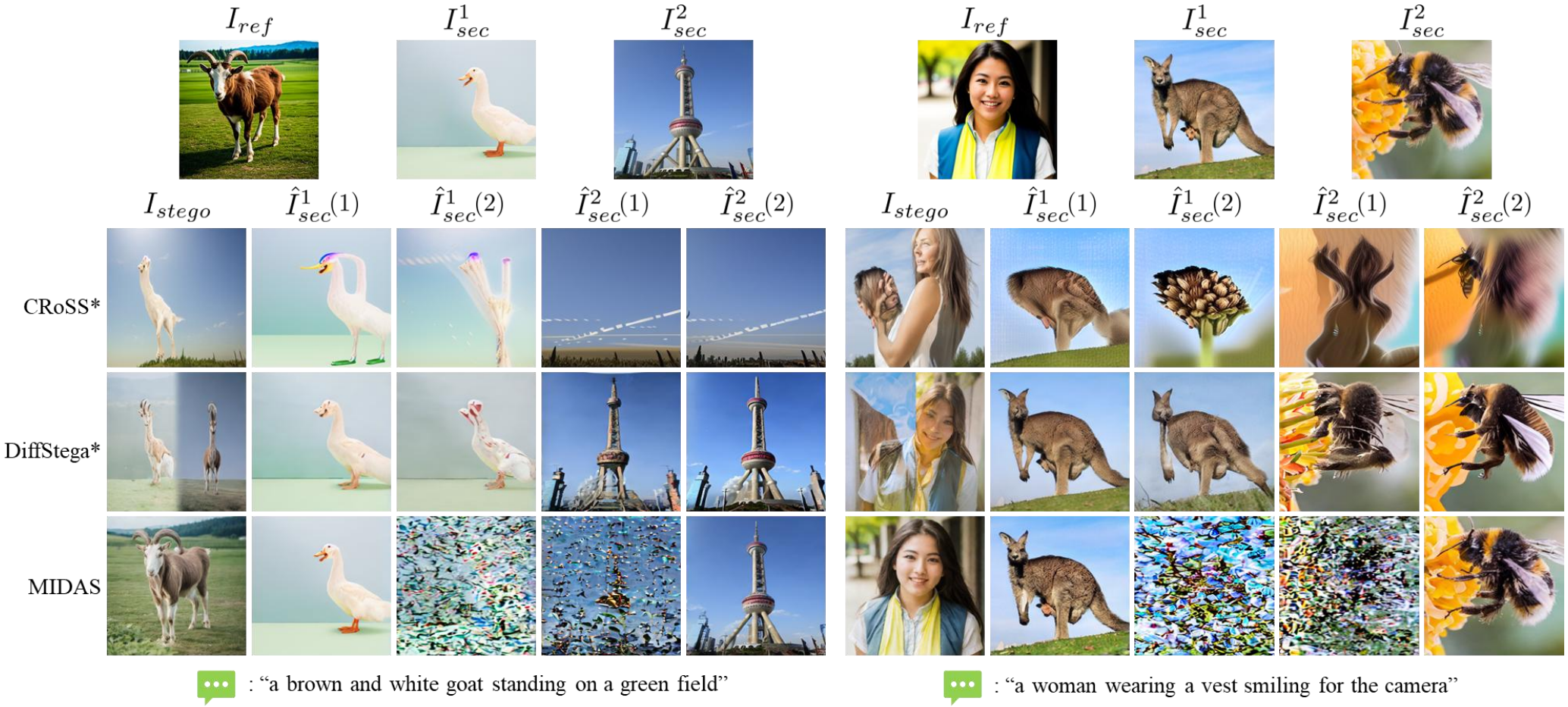
Latent Vector Fusion/Decomposition

- Shuffles concatenated secret representations.
- Injects reference information to improve generation quality.
- Uses only publicly available resources.



Qualitative Results



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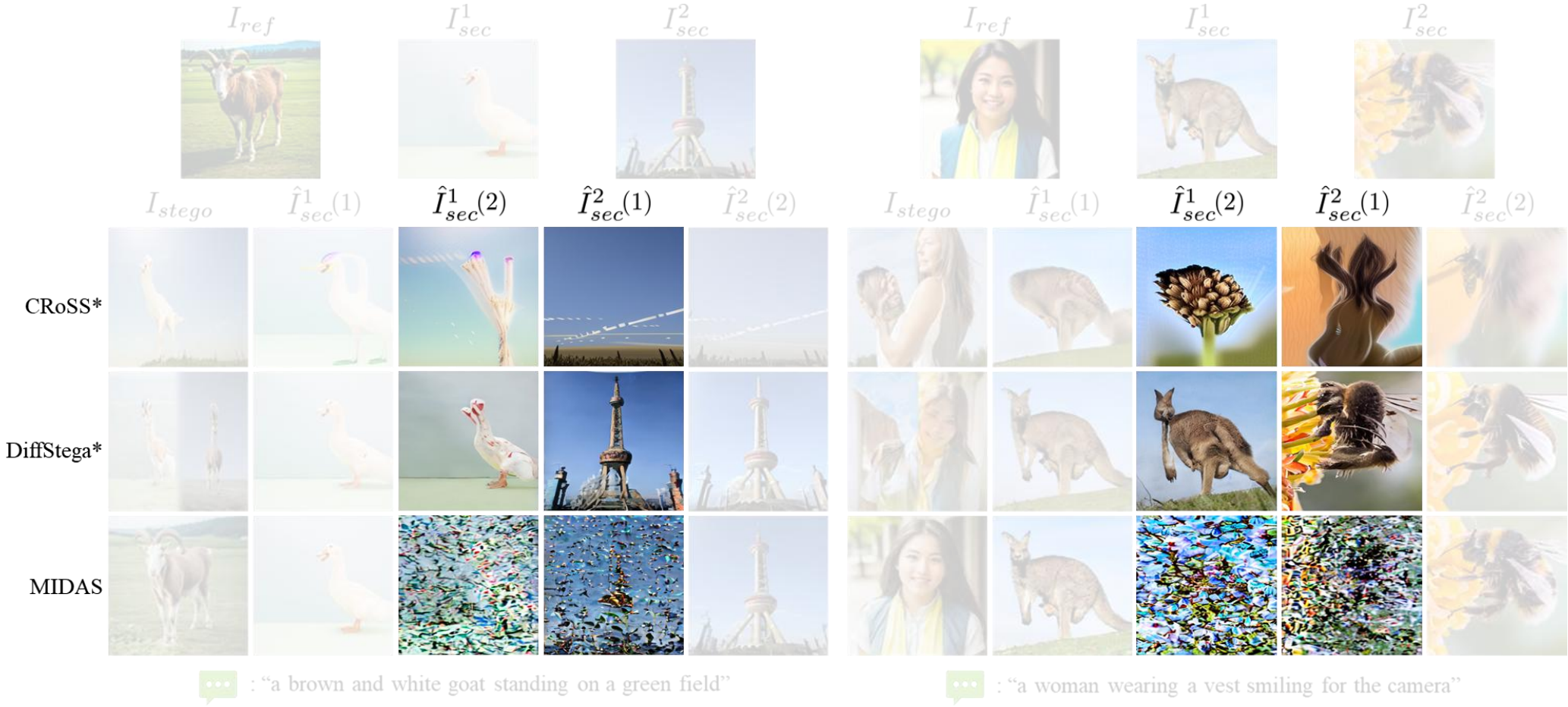

Quantitative Results

Table 2. Quantitative results for stego and reconstructed images on the Stego260 dataset. Best results among training-free CIS methods are highlighted in **bold**.

N	Method	Stego image quality	Stego image diversity				Correct $\mathcal{K}_{priv}$ reconstruction			Wrong $\mathcal{K}_{priv}$ reconstruction		
		MANIQA↑	PSNR↓	SSIM↓	LPIPS↑	CLIP Score↑	PSNR↑	SSIM↑	LPIPS↓	PSNR↓	SSIM↓	LPIPS↑
1	IIS	-	-	-	-	-	48.588	0.999	0.016	10.551	0.107	0.818
	AIS	-	-	-	-	-	35.990	0.999	0.127	22.981	0.595	0.367
	CRoSS*	0.409	20.535	0.740	0.322	27.937	22.870	0.796	0.263	18.387	0.650	0.430
	DiffStega*	**0.450**	19.686	0.664	0.419	28.871	24.958	**0.833**	**0.232**	19.447	0.650	0.397
	MIDAS(Ours)	0.429	**13.407**	**0.419**	**0.610**	**29.686**	**25.161**	0.831	0.234	**12.718**	**0.237**	**0.698**
2	IIS	-	-	-	-	-	41.360	0.995	0.070	11.883	0.219	0.808
	AIS	-	-	-	-	-	30.724	0.973	0.317	4.540	0.126	0.847
	CRoSS*	0.406	15.550	0.521	0.579	26.071	17.606	0.563	0.496	15.270	0.470	0.576
	DiffStega*	0.399	17.065	0.531	0.555	26.952	21.908	0.728	0.344	18.137	0.587	0.458
	MIDAS(Ours)	**0.434**	**9.885**	**0.287**	**0.752**	**30.129**	**23.903**	**0.771**	**0.299**	**9.964**	**0.090**	**0.753**
4	IIS	-	-	-	-	-	33.540	0.976	0.184	15.783	0.338	0.686
	AIS	-	-	-	-	-	28.045	0.956	0.369	5.131	0.126	0.947
	CRoSS*	0.418	13.445	0.453	0.687	24.601	13.190	0.312	0.681	12.731	0.297	0.696
	DiffStega*	0.364	16.160	0.509	0.600	27.367	19.233	0.609	0.442	17.533	0.545	0.508
	MIDAS(Ours)	**0.479**	**8.996**	**0.296**	**0.787**	**30.169**	**22.283**	**0.697**	**0.359**	**9.399**	**0.118**	**0.763**

Anti-Steganalysis

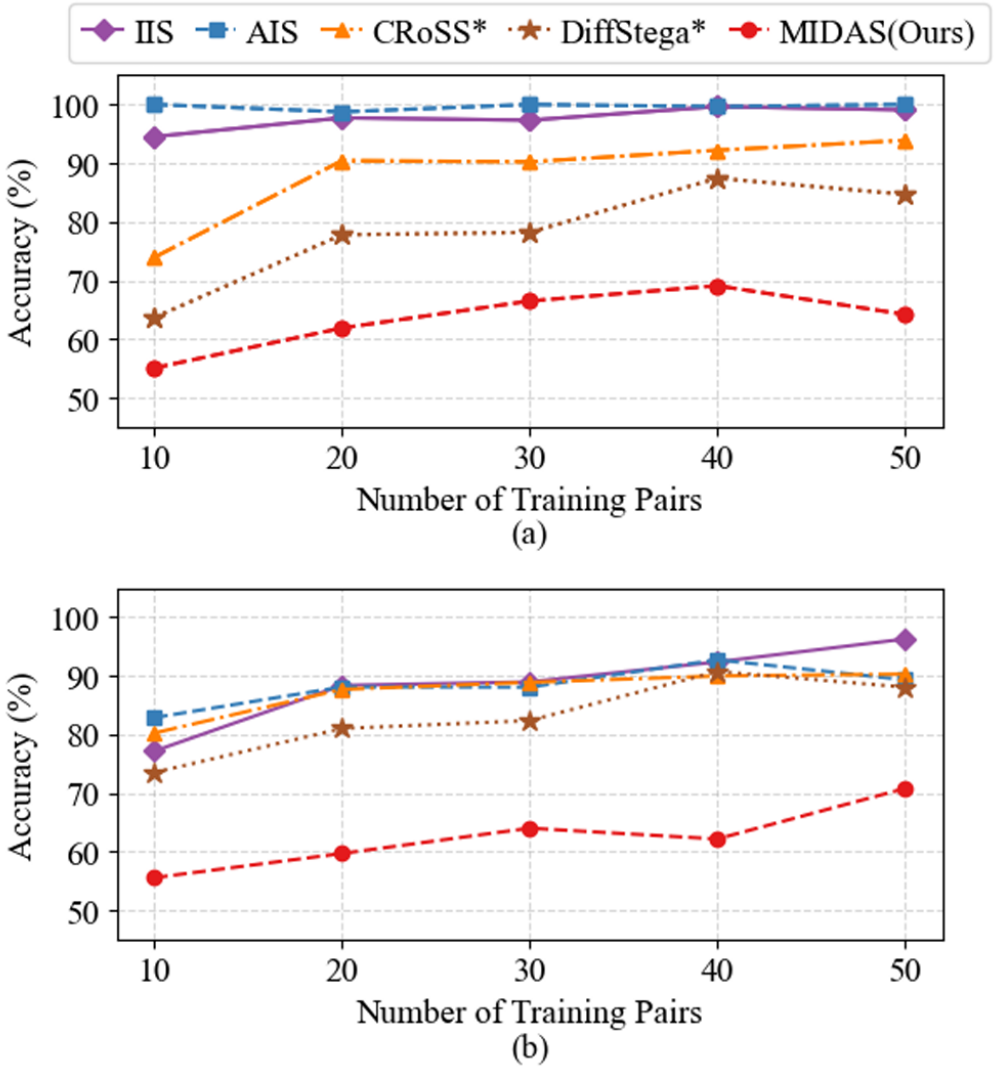

Figure 4. Steganalysis accuracy on (a) XuNet and (b) SiaStegNet.

Key Contributions

- Training-free multi-image CIS with access control
- Information-theoretic security guarantees
- Visually natural stego images with strong resistance to steganalysis

Thank you

Paper

Code